WHAT IS CLAIMED IS:

1. A force detection device comprising:

a base plate, having a top surface parallel to an XY plane in an XYZ three-dimensional coordinate system having an X-axis, a Y-axis and a X-axis;

a first displaceable plate, positioned along a plane intersecting a positive part of the X-axis and supported on said base plate in a displaceable manner;

a second displaceable plate, positioned along a plane intersecting a negative part of the X-axis and supported on said base plate in a displaceable manner;

a first fixed plate, positioned between the Z-axis and said first displaceable plate and fixed onto said base plate;

a second fixed plate, positioned between the Z-axis and said second displaceable plate and fixed onto said base plate;

a fixed top plate, positioned along a plane spanning across a vicinity of an upper edge of said first fixed plate and a vicinity of an upper edge of said second fixed plate;

a displaceable top plate, positioned above said fixed top plate, supported so as to be displaceable with respect to said base plate, and transmitting, to an upper edge of said first displaceable plate and an upper edge of said second displaceable plate, a force in a direction along the XY plane;

a force receiving member, positioned on the Z-axis above said displaceable top plate in order to receive a force that is to be detected;

a connecting member, positioned along the Z-axis in order to connect said force receiving member and said displaceable top plate;

a first X-axis distance sensor, detecting a distance between said first displaceable plate and said first fixed plate;

a second X-axis distance sensor, detecting a distance between said second displaceable plate and said second fixed plate;

an inclination degree sensor, detecting an inclination degree of said displaceable top plate with respect to said fixed top plate; and

a detection processing unit, detecting a force Fx in the X-axis direction, acting on said force receiving member, based on a difference between a detection value of said first X-axis distance sensor and a detection value of said second X-axis distance sensor, and detecting a moment My about the Y-axis, acting on said force receiving member, based on a detection value of an inclination degree in relation to the X-axis direction that is detected by said inclination degree sensor.

2. The force detection device according to claim 1, further comprising:

a third displaceable plate, positioned along a plane intersecting a positive part of the Y-axis and supported on said base plate in a displaceable manner;

a fourth displaceable plate, positioned along a plane intersecting a negative part of the Y-axis and supported on said base plate in a displaceable manner;

a third fixed plate, positioned between the Z-axis and said third displaceable plate and fixed onto said base plate;

a fourth fixed plate, positioned between the Z-axis and said fourth displaceable plate and fixed onto said base plate;

a first Y-axis distance sensor, detecting a distance between said third displaceable plate and said third fixed plate; and

a second Y-axis distance sensor, detecting a distance between said fourth displaceable plate and said fourth fixed plate; and

wherein the detection processing unit detects a force Fy in the Y-axis direction, acting on the force receiving member, based on a difference between a detection value of said first Y-axis distance sensor and a detection value of said second Y-axis distance sensor, and detects a moment Mx about the X-axis, acting on the force receiving member, based on a detection value

of an inclination degree in relation to the Y-axis direction that is detected by said inclination degree sensor.

3. The force detection device according to claim 1:

a Z-axis distance sensor, detecting a distance between the displaceable top plate and the fixed top plate;

wherein the detection processing unit detects a force Fz in the Z-axis direction, acting on the force receiving member, based on a detection value of said Z-axis distance sensor.

4. The force detection device according to claim 1:

a rotation angle sensor, detecting a rotation angle about the Z-axis of the displaceable top plate with respect to the fixed top plate;

wherein the detection processing unit detects a moment Mz about the Z-axis, acting on the force receiving member, based on a detection value of said rotation angle sensor.

5. The force detection device according to claim 1:

wherein fixed electrodes are formed on surfaces of the fixed plates that oppose the displaceable plates, displaceable electrodes are formed on surfaces of the displaceable plates that oppose the fixed plates, and distance sensors for detecting distances between said fixed plates and said displaceable plates are arranged by capacitance elements, each comprising a fixed electrode and a displaceable electrode that oppose each other, to enable detection of distances based on static capacitance values of said capacitance elements.

6. The force detection device according to claim 1:

wherein, when the X-axis and the Y-axis are projected onto a top surface of the fixed top plate, a first fixed electrode is formed on a projected image of a positive part of the X-axis and a second fixed electrode is formed on a projected image of a negative part of the X-axis;

wherein, on a bottom surface of the displaceable top plate,

a first displaceable electrode is formed at a position opposing said first fixed electrode and a second displaceable electrode is formed at a position opposing said second fixed electrode; and

wherein a first capacitance element is constituted of said first fixed electrode and said first displaceable electrode, a second capacitance element is constituted of said second fixed electrode and said second displaceable electrode, and these two capacitance elements are used as an inclination degree sensor arranged to detect an inclination degree in relation to the X-axis direction, based on a difference between a static capacitance value of said first capacitance element and a static capacitance value of said second capacitance element.

7. The force detection device according to claim 2:

wherein, when the X-axis and the Y-axis are projected onto a top surface of the fixed top plate, a first fixed electrode is formed on a projected image of a positive part of the X-axis, a second fixed electrode is formed on a projected image of a negative part of the X-axis, a third fixed electrode is formed on a projected image of a positive part of the Y-axis, and a fourth fixed electrode is formed on a projected image of a negative part of the Y-axis;

wherein, on a bottom surface of the displaceable top plate, a first displaceable electrode is formed at a position opposing said first fixed electrode, a second displaceable electrode is formed at a position opposing said second fixed electrode, a third displaceable electrode is formed at a position opposing said third fixed electrode, and a fourth displaceable electrode is formed at a position opposing said fourth fixed electrode; and

wherein a first capacitance element is constituted of said first fixed electrode and said first displaceable electrode, a second capacitance element is constituted of said second fixed electrode and said second displaceable electrode, a third capacitance element is constituted of said third fixed

electrode and said third displaceable electrode, a fourth capacitance element is constituted of said fourth fixed electrode and said fourth displaceable electrode, and these four capacitance elements are used as an inclination degree sensor arranged to detect an inclination degree in relation to the X-axis direction, based on a difference between a static capacitance value of said first capacitance element and a static capacitance value of said second capacitance element, and to detect an inclination degree in relation to the Y-axis direction, based on a difference between a static capacitance value of said third capacitance element and a static capacitance value of said fourth capacitance element.

8. The force detection device according to claim 5:

wherein, with respect to a fixed electrode and a displaceable electrode that constitute a capacitance element, an area of one electrode is set wider than an area of the other electrode so that a static capacitance value will not change when the displaceable electrode undergoes a displacement within a predetermined range in a planar direction.

9. The force detection device according to claim 8:

wherein, the fixed plates and the fixed top plate, or the displaceable plates and the displaceable top plate are formed of a conductive material, and the fixed plates and the fixed top plate, or the displaceable plates and the displaceable top plate are in themselves used as a fixed electrode or a displaceable electrode.

10. The force detection device according to claim 8:

wherein a box-like structure is formed by mutually joining the displaceable top plate and the plurality of displaceable plates, formed of a conductive material, and said box-like structure is used as a single, common displaceable electrode.

11. The force detection device according to claim 4:

wherein fixed electrodes are formed on a top surface of the fixed top plate, displaceable electrodes are formed on a bottom surface of the displaceable top plate, and the rotation angle sensor, detecting a rotation angle about the Z-axis of said displaceable top plate with respect to said fixed top plate, is arranged by capacitance elements, each comprising a fixed electrode and a displaceable electrode that oppose each other, to enable a detection of the rotation angle based on static capacitance values of said capacitance elements.

12. The force detection device according to claim 11:

wherein the displaceable electrodes are positioned at positions that are offset in a predetermined rotation direction with respect to positions that oppose the fixed electrodes to enable detection of a rotation direction along with the rotation angle based on increases or decreases of static capacitance values of the capacitance elements.

13. The force detection device according to claim 12:

wherein, when the X-axis and the Y-axis are projected onto a top surface of the fixed top plate, a first fixed electrode is formed on a projected image of a positive part of the X-axis, a second fixed electrode is formed on a projected image of a negative part of the X-axis, a third fixed electrode is formed on a projected image of a positive part of the Y-axis, and a fourth fixed electrode is formed on a projected image of a negative part of the Y-axis;

wherein, on a bottom surface of the displaceable top plate, a first displaceable electrode is formed at a position offset in a predetermined rotation direction with respect to a position opposing said first fixed electrode, a second displaceable electrode is formed at a position offset in a rotation direction with respect to a position opposing said second fixed electrode, a third displaceable electrode is formed at a position offset in a rotation direction with respect to a position opposing said third fixed electrode, and a fourth displaceable electrode is

formed at a position offset in a rotation direction with respect to a position opposing said fourth fixed electrode; and

wherein a first capacitance element is constituted of said first fixed electrode and said first displaceable electrode, a second capacitance element is constituted of said second fixed electrode and said second displaceable electrode, a third capacitance element is constituted of said third fixed electrode and said third displaceable electrode, a fourth capacitance element is constituted of said fourth fixed electrode and said fourth displaceable electrode, and detection of a rotation direction along with a rotation angle is enabled based on an increase or a decrease of a sum of static capacitance values of the four capacitance elements.

14. The force detection device according to claim 1:

wherein an outer box-like structure, forming a rectangular parallelepiped that is opened at a bottom surface and undergoing elastic deformation by an action of an external force, is joined so that said bottom surface is set on the base plate, side plates or a part thereof of said outer box-like structure are used as the displaceable plates, and a top plate or a part thereof of said outer box-like structure is used as the displaceable top plate.

15. The force detection device according to claim 14:

wherein U-shaped slits, opening upward, are formed in side plates of the outer box-like structure and respective parts surrounded by the respective slits are used as the displaceable plates.

16. The force detection device according to claim 15:

wherein the U-shaped slit, opening upward, is formed in each of four side plates of the outer box-like structure, edges at which two mutually adjacent side plates intersect are used as columns to arrange a structure, with which a top plate of said outer box-like structure is supported by a total of four

pillars, and said outer box-like structure is made to deform by elastic deformation of the four columns.

17. The force detection device according to claim 14:

wherein an inner box-like structure, forming a rectangular parallelepiped that is smaller than the outer box-like structure, is joined onto the base plate in a state in which said inner box-like structure is contained in said outer box-like structure and side plates and a top plate of said inner box-like structure are used as the fixed plates and the fixed top plate.

18. The force detection device according to claim 1:

wherein four columns, formed of a material that undergoes elastic deformation due to an action of an external force and joined in an erected manner to the base plate, and a top plate, four corners of which are joined to upper ends of said four columns are provided; and

wherein the displaceable plates are positioned between respective pairs of mutually adjacent columns, upper edges of the displaceable plate are joined to and thereby supported by edges of said top plate, and said top plate or a part thereof is used as the displaceable top plate.

19. The force detection device according to claim 14:

wherein by forming slits in the top plate, said top plate is partitioned into a displaceable top plate positioned at a center, peripheral parts positioned at a periphery of said displaceable top plate, and beams having flexibility and connecting said displaceable top plate and said peripheral parts, so that said displaceable top plate is displaced with respect to said peripheral parts by a deflection of said beams and said peripheral parts are connected to the base plate via side plates or columns of the outer box-like structure.

20. The force detection device according to claim 19:

wherein when the X-axis and the Y-axis are projected onto the top plate, a displaceable top plate having a shape of vanes of a fan is arranged from a first vane-like part, positioned on a projected image of a positive part of the X-axis, a second vane-like part, positioned on a projected image of a negative part of the X-axis, a third vane-like part, positioned on a projected image of a positive part of the Y-axis, a fourth vane-like part, positioned on a projected image of a negative part of the Y-axis, and a central part, positioned on a projected image of an origin O and connected to inner side parts of said first to fourth vane-like parts;

wherein a respective beam is positioned between every two mutually adjacent vane-like parts so that said central part is supported by four beams; and

wherein said four beams are connected to said central part at their inner ends and connected to the peripheral parts at their outer ends and the connecting member is connected to a top surface of said central part.

21. The force detection device according to claim 20:

wherein each beam comprises: a horizontal beam, whose main surface faces a horizontal direction; a vertical beam whose main surface faces a vertical direction; and an intermediate joint, connecting said horizontal beam and said vertical beam; and is thereby made a structure with which both deflection in the horizontal direction and deflection in the vertical direction can occur readily.

22. The force detection device according to claim 1:

wherein a control member is provided, which, in order to restrict displacements of the force receiving member with respect to the base plate within predetermined ranges, has control surfaces that contact said force receiving member when said force receiving member is about to become displaced beyond said predetermined range.

23. The force detection device according to claim 22:

wherein at least a part of the force receiving member and a part of the control member that are involved in contact are formed of a conductive material, and a contact detection circuit, detecting a state of contact of said force receiving member and said control member based on a state of electrical conduction, is provided.

24. The force detection device according to claim 23:

wherein a hollow part is formed in a vicinity of a control surface of the control member or an opposing surface of the force receiving member that opposes said control surface, a surface layer part at which the hollow part is formed is arranged as a thin part with flexibility, a conductive contact protrusion is formed on a surface of said thin part, and a state of electrical conduction by contacting of said contact protrusion with said opposing surface or said control surface is arranged to be detected prior to contacting of said opposing surface and said control surface.

25. The force detection device according to claim 24:

wherein a conductive conical protrusion, a tip part of which undergoes plastic deformation, is provided on the control surface of the control member or a surface of the force receiving member that opposes said control surface.